ORIGINAL RESEARCH

Minimizing the learning curve for robotic-assisted radical cystectomy

A single-surgeon, retrospective, cohort study

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ABSTRACT

INTRODUCTION: Studies published to date have suggested non-inferiority of robotic-assisted radical cystectomy (RARC) compared to open radical cystectomy (ORC), while few centers in Canada have adopted this approach. Though multifactorial, the learning curve and operative time are often discussed barriers. Herein, we present outcomes from the largest Canadian cohort of RARC performed to date.

METHODS: We conducted a retrospective chart review of all patients undergoing RARC by a single surgeon with greater than 1500 robot-assisted radical prostatectomy (RARP) experience at our institution from May 2020 to December 2021. Clinicopathological, intraoperative, and postoperative data, as well as complications in the first 90 days, were collected. Regression analysis was used to determine the relationship between case volume and operative time/lymph node yield.

RESULTS: A total of 31 patients underwent RARC during the study period, 26 of which were male. The median length of stay was six days (Q1–Q3 5–10), while days alive and out of hospital at 90 days were 83 days (Q1–Q3 80–85). Soft tissue margins were positive in 9.6% (3/31) of patients. Median lymph node yield was 17.0 lymph nodes (Q1–Q3 11–23). Median operative time was 241 minutes (Q1–Q3 228–252) in the ileal conduit group and 320 minutes (Q1–Q3 302–337) in the neobladder group. We observed four Clavien-Dindo grade ≥3_complications. The 90-day readmission rate and mortality rate were 17.2% (5) and 0% (0), respectively. There was no correlation between case volume and any outcome variables.

CONCLUSIONS: Previous high-volume experience performing RARP reduces the learning curve for performing RARC, with similar short-term outcomes to high-volume centers.

INTRODUCTION

Bladder cancer is projected to be the fifth most common malignancy in Canadians in 2022, with approximately 13 000 cases diagnosed annually. Of those, 25% are muscle-invasive, with a 40% five-year mortality rate.[1] Radical cystectomy is considered the gold-standard treatment of muscle-invasive bladder cancer.[2,3] As minimally invasive surgery has become incorporated into multiple aspects of urology, laparoscopic and robotic-assisted approaches have been explored in this setting. Laparoscopic radical cystectomy was first described in the early 2000s but adoption of the approach was initially limited due to the technical challenges of the procedure, operating time, and a steep learning curve.

To date, randomized controlled trials comparing open radical cystectomy (ORC) to robotic-assisted radical cystectomy (RARC) have provided evidence to support non-inferiority.[4,5] Studies available in the literature for RARC have reported a mean operative time ranging from 252–456 minutes, estimated blood loss (EBL) of 200–585 mL, lymph node count of 9–31, positive surgical margin rate of 0–15%, and a complication rate 25–67%.[4-8] None of these studies have included patients from any Canadian centers.

The learning curve has been infrequently reported on to date. Pruthi and colleagues reported on their first 50 RARCs, showing an improvement in EBL and operative

time that appeared to plateau after the first 30 cases.[9] Using consecutive patients from 14 different institutions, it was shown that 21 cases were required to reach an operative time less than 390 minutes, and 30 cases for a lymph node count of 20, as well as a positive surgical margin rate less than 5%. Of those who participated in the study, prior robot-assisted radical prostatectomy (RARP) experience was variable, ranging from less than 50 to greater than 150 cases.[10] Guru and colleagues performed 100 consecutive RARCs showing only a minimal improvement in operative time but improved lymph node yield and fewer positive surgical margins with increased experience.[11] Depending on the outcome variable assessed, it appears that there is a different learning curve for each portion of the procedure.[12] In this retrospective cohort study, our objective was to evaluate the outcomes of the first 31 RARCs at our high-volume robotic center.

METHODS

We performed a retrospective chart review of the first 31 RARCs performed using the DaVinci Xi platform (© 2023 Intuitive Surgical. All rights reserved) at our center by a single surgeon with more than 1500 RARP case experience. Consecutive patients referred to our center and elected for surgical management were included in the study. Selection of urinary diversion, as well as intra- or extracorporeal creation was determined at the discretion of the surgeon. In men, the prostate and seminal vesicles were taken in addition to the bladder, while in women, the ovaries, uterus, anterior vagina, and uterus were removed. All patients underwent an extended pelvic lymph node dissection (common iliac, external iliac, internal iliac and obturator). Preoperative bowel preparation was not used, and patients did not receive alvimopan, as it is not available in Canada. All patients received 28 days of venous thromboembolism prophylaxis in the postoperative period. The study was exempted by the institutional research ethics board at our center.

Patients had routine followup within two weeks of hospital discharge and at six weeks postoperative to review final pathology. Thereafter, followup was at the discretion of the surgeon. Variables up to 90 days postoperatively were collected for all patients. The covariates collected included patient demographics, clinicopathologic data, and perioperative and postoperative outcomes. Operative time was measured from initial skin incision to skin closing, including docking of the robot. Surgical complications were reported using the Clavien-Dindo classification system.[13] Descriptive statistics were reported as medians and interquartile ranges (Q1–Q3). Dichotomous variables were reported as proportions. Linear regression analysis was used to assess the relationship between case volume and operative time or lymph node yield. Statistical analysis was conducted in RStudio 2020 (PBC, Boston, MA, U.S.).

RESULTS

Between May 2020 and December 2021, a total of 31 patients underwent RARC and were included in our study, none of which had received prior radiotherapy (Table 1). All cystectomies performed by our surgeon during this time were robotic-assisted. Most patients were male (26/31), under the age of 70 (median 67, Q1–Q3 59–72), of normal body mass index (median 25.7, Q1–Q3 23–29), and functional capacity (Eastern Cooperative Oncology Group [ECOG] 0; n=20/31).

Table 1. Baseline demographics

Male (%, n)	83% (26)
Age (years, median [Q1–Q3])	67 [59–72]
BMI (kg/m^2, median [Q1–Q3])	25.7 [23–29]
GFR <30 mL/min (%, n)	3.2% (1)
ECOG status (%, n)	
0	64.5% (20)
1	32.2% (10)
≥2	3.2% (1)
ASA class	
≤2	3.2% (1)
3	67.7% (21)
≥4	29.0% (9)
Clinical stage (%, n)	
CIS	6.5% (2)
Ta	3.2% (1)
T1	19.4% (6)
T2	48.4% (15)
T3	16.1 %(5)
T4	3.2% (1)
Metastatic	3.2% (1)
Neoadjuvant chemotherapy (%, n)	48.3% (15)

ASA: American Society of Anesthesia BMI: body mass index; ECOG: Eastern Cooperative Oncology Group; GFR: glomerular filtration rate; Q1: first quartile; Q3: third quartile.

Table 2. Operative, perioperative, and oncological outcomes

Estimated blood loss (mL, median [Q1–Q3])	300 [150–350]
Transfusion rate (%, n)	12.9% (4)
Diversion (%, n)	
Ileal conduit	80.6% (25)
Neobladder	19.3% (6)
Complications (%, n)	45% (14)
Clavien-Dindo <3	32.2% (10)
Clavien-Dindo ≥3	12.9% (4)
Operative time (minutes, median [Q1–Q3])	
Ileal conduit	241 [228–252]
Neobladder	320.5 [302–337]
Positive soft tissue margins (%, n)	9.6% (3)
Final pathology (%, n)	
T0	6.5% (2)
CIS	9.7% (3)
Ta	6.5% (2)
T1	16.1% (5)
T2	19.3% (6)
T3	29.0% (9)
T4	12.9% (4)
Lymph node yield (median [Q1–Q3])	17.0 [11–23]
Days till flatus (median [Q1–Q3])	3.0 [2–4]
Length of stay (days, median [Q1–Q3])	6 [5–10]
Days alive and out of hospital at 90 days (days, median [Q1–Q3])	83.0 [80–85]

Q1: first quartile; Q3: third quartile.

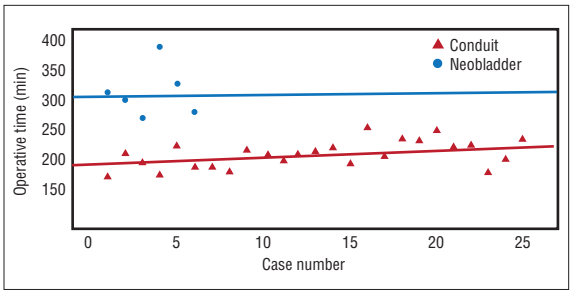

Figure 1. Linear regression assessing correlation between operative time with case volume for the ileal conduit cohort (red; R^2=0.2, p=0.02) and for the neobladder cohort (blue; R^2=0.002, p=0.94).

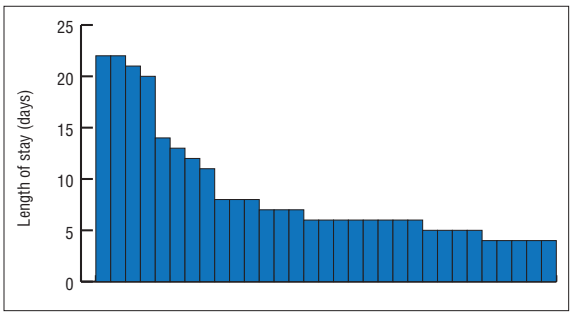

Figure 2. Waterfall plot of length of stay in hospital for each individual patient.

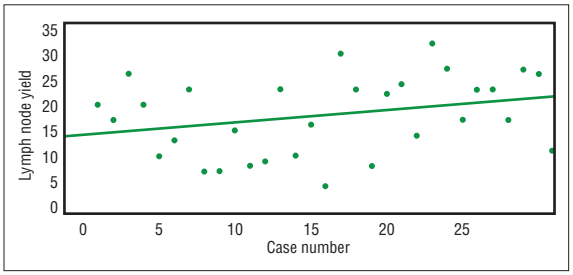

Figure 3. Linear regression assessing correlation between lymph node yield and case volume (R^2=0.054, p=0.10).

American Society of Anesthesia (ASA) class was greater than or equal to four in 9/31 patients, with a median of three. Seven patients had a prior history of abdominal surgery, while 15/31 patients received neoadjuvant chemotherapy. Most operations were for muscle-invasive disease (21/31), while 29.0% (9/31) were performed for high-grade non-muscle-invasive disease or carcinoma in situ (CIS) in which previous intravesical therapy failed. A single palliative cystectomy for intractable hematuria in a metastatic patient with a profound response to systemic chemotherapy was included.

Perioperative outcomes are listed in Table 2. A total of 25/31 patients underwent an incontinent urinary diversion. Median operative time for patients undergoing an ileal conduit was 241.0 (Q1–Q3 228–252) minutes in comparison to 320.5 (Q1–Q3 302–337) minutes for those undergoing a neobladder urinary diversion. All neobladders (6/6) and 4% (1/25) of conduits were performed intracorporeally. Linear regression showed an increase in operative time with increasing case volume for ileal conduits (p=0.02) (Figure 1).

In this cohort, no intraoperative complications, conversions to open surgery, or postoperative admission to the ICU occurred. The median length of stay was six days (Q1–Q3 5–10) (Figure 2). Postoperative complications were observed in 14/31 (45%) patients, four of which (12.9%) were Clavien-Dindo grade ≥3 complications. Four patients required transfusions, two of which

were conducted intraoperatively due to low baseline hemoglobin, and two were performed postoperatively. The most common complication was ileus necessitating nasogastric tube insertion or use of total parenteral nutrition (16.1%, 5/31) followed by asymptomatic myocardial injury following non-cardiac surgery (9.6%, 3/31). For the grade ≥3 complications, two patients developed right ureteric stricture within the first 90 days requiring nephrostomy tube insertion, one patient developed a urine leak requiring percutaneous drain placement, and one patient required a re-operation secondary to a small bowel anastomotic leak. Five (16.1%) patients were readmitted to hospital in the first 90 days. No mortality was noted in this patient population during the first 90 days. At 90 days postoperatively, median days alive and out of hospital for all patients was 83.0 (Q1–Q3 80–85) days.

Of the patients with a positive soft tissue margin (9.6%, 3/31), two patients had greater than N2 disease on final pathology. Two patients' final pathology showed CIS at the ureter/urethral margin. Median lymph node count was 17.0 (Q1–Q3 11–23) nodes per case. Linear regression did not find any correlation between case volume and lymph node yield (Figure 3).

DISCUSSION

The learning curve and operative time required for RARC have been described as major barriers to its widespread adoption. Herein, we demonstrate that the learning curve for RARC is minimized with prior high-volume RARP experience. Operative time, lymph node count, length of stay, and days alive and out of hospital at 90 days are comparable between our cohort and the two landmark surgical trials comparing RARC and ORC.[4,5] Additionally, positive soft tissue margins, as well as major and minor complication rates were similar between the first set and last cohorts, and comparable to modern estimates of predominately ORC.[14]

The International Robotic Cystectomy Consortium reported 30 procedures needed to reach an average operative time of 390 minutes and average lymph node count of 20.[10] Guru et al suggest that operative time plateaued after the first 16 cases for extracorporeal diversion, with a mean operative time of 352 minutes in their final cohort, although their mean lymph node count drastically increased from 14 to 23.[11] Including both extracorporeal ileal conduit and neobladder, Nix and colleagues showed a mean operative time of 252 minutes, EBL of 258 mL, and lymph node count of 19 nodes, although prior robotic experience is not specified and their initial published mean operative time was 397 minutes, EBL 278 mL, and lymph node count 16.[8,15] Therefore, their experience likely stemmed from the first 23 patients, suggesting a minimum of 23 case experience. Our mean lymph node count was above the minimum suggested number of 12, and modern nomograms did not identify any correlation between lymph node count and cancer-specific survival.[16,17] Our results demonstrate that we had achieved lower operative times and similar oncological outcomes to high-volume RARC centers early in our experience with the procedure.

Limitations

There are several limitations to our study. Followup was limited to the first 90-days postoperatively, and as such, long-term surgical (stoma revision, stricture formation) and oncological outcomes are not reported. Furthermore, the retrospective data does not allow us to control for experimentation in surgical technique in our early experience. The only change in operative technique gathered from operative notes was a switch to intracorporeal conduit for the final case in the series. Experimentation with technique may explain why operative time increased in the ileal conduit group. Sharing of steps with robotic fellows may also contribute to this operative time. Given that our data derives from a single surgeon at a single center, it may not be generalizable to other centers, specifically centers without similar robotic case volumes per surgeon. Furthermore, while this is the first Canadian series on RARC, the sample size is small, limiting the conclusions we can draw from it. Lastly, data regarding cost analysis and patient-reported quality of life outcomes were not collected.

CONCLUSIONS

When adopted by a high-volume RARP surgeon, RARC is feasible and safe, with similar operative and oncological outcomes to high-volume centers, suggesting there may be less of a learning curve than previously described in the literature.

COMPETING INTERESTS: The authors do not report any competing personal or financial interests related to this work.

This paper has been peer-reviewed.

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